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ABSTRACT

The purpose of this paper is to provide a conceptual foundation for the development of hypermedia as an instructional tool for addressing individual learning style differences. Various learning theories and their relationship to hypermedia are examined, including information processing theory, semantic networks, concept webbing/mapping, frames/scripting, and schema theory from the works of Piaget. Theory and learning styles are then addressed, including Witkin's field dependence and field independence, Kolb's learning styles, multidimensional learning styles, sensory modalities, and brain hemispherity. Research on the application of CAI/HAI (Computer Assisted Instruction/Hypermedia Assisted Instruction) and learning styles is reviewed. Differences between CAI and HAI are noted, and areas for future research are suggested. (Contains 61 references.) (ALF)

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AN OVERVIEW OF THE RESEARCH ON LEARNING STYLES AND HYPERMEDIA ENVIRONMENTS

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by

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Introduction

It is generally recognized that the computer can function as a motivator for learning to many students by helping to make learning more interesting. From the earliest to the most recent applications of the computer in education, there has continuously been the need to match the learner with the instruction. Different types of computer-assisted instruction (CAI) have been used to create computer learning environments that will effectively target uniquely different segments of the learner population. Not all students have done equally well with CAI, nor have all students even benefitted. Specific groups of students (i.e., low ability) have been the ones to benefit the most from CAI. Unfortunately, the trend has been to present a standard form of instruction that has forced the student to adapt. This approach has not been overly successful. There is no longer a need to force the student to change in an effort to accommodate the instruction. Current technology allows learners of different backgrounds, varying abilities, and of different learning styles to enter a learning environment in which all of their individual needs can be addressed. This technology is called hypermedia.

Hypermedia integrates text, sound, graphics, and video to provide a more comprehensive illustration of a single concept. Hypermedia is the integration of many facets of technology. Rather than using the tools of the educator in separate forms as multimedia, the integration of these components has allowed for a much richer learning environment. This multi-modal approach to learning can benefit students who have often been neglected by more traditional forms of instruction. "Hypertext and hypermedia are seen as having great potential because they offer a convenient way to represent subject matter knowledge and model the structure of knowledge. If learning occurs when new knowledge is integrated into a pre-existing web of knowledge, then it stands to reason that teaching should incorporate this concept in presentation of material" (Marsh & Kumar, 1992, p. 27). Not only does hypermedia allow one to efficiently store and use a veritable wealth of information, but it can also be used to explore the relationships among these many ideas. Other uses are to create individual groupings of related information, establish new linkages, and to author entirely new instruction.

The purpose of this paper is to provide a conceptual foundation for the development of hypermedia as an instructional tool for addressing individual learning style differences. Research in this area is only now beginning to emerge and the results appear to be fulfilling some of the many earlier promises of hypermedia technology.

Theory and Hypermedia

The use of the computer as a metaphor to represent human knowledge structures is a common method of explaining how we store and retrieve information. The emergence of the *information processing theory* following World War II was the origin for this metaphor. The dawn of the computer-age accelerated the popularity of this cognitive theory which studies the learner's organization of thinking, one's strategies for problem solving, the process of learning, and the role of meaning in learning. By addressing questions previously ignored by behavioral theories, the information processing theory has gained a large following and has focused on areas such as the nature of the learner who is described as being "an active interpreter and manipulator of environmental stimuli" (Biehler & Snowman, 1990, p. 377).

There are many different mental models, which combined, explain the storage and retrieval of information as well as the representation of knowledge within memory. The most commonly used information processing model describes how information *flows* within an organism. This process involves the sensory registers, short term memory, and long term memory. This *process* is not the focus of this paper. Other models have developed which describe how we *represent* this information once it is stored in memory. There are many methods of describing knowledge representation, and they take varying forms. But all of these models maintain a common underlying theme. Each model

emphasizes the importance of *prior knowledge* and *experience* as they affect the acquisition of new information. Several of these models have become the theoretical basis for the design of hypermedia instruction. These models stress the importance of providing the learner with a rich and stimulating environment in which numerous patterns of thought can emerge by connecting and relating concepts. The importance of providing the learner with a multitude of experiences from a rich environment is emphasized by Bruner (1969), who states that "stimulus heterogeneity at an early age is a crucial ingredient in intellectual growth" (Sprinthall & Sprinthall, 1990, p. 79). The models which have had the greatest impact on the development of hypermedia include *semantic networks, concept webbing/mapping, frames/scripting,* and *schema theories.* It is evident that "hypermedia provides a computerized technology to achieve similar organizational structures" (Palumbo & Prater, in press, p. 5). Information representation within hypermedia and the models used to represent information within human memory appear very similar. In fact, "hypermedia systems which focus on knowledge representation may readily parallel the theoretical organization of human memory" (Nelson & Palumbo, 1992, p. 294).

Semantic Networks

The concept of *semantic networks* was pioneered by Quillian (1968) and provides a diagrammatical method of representing information within human memory (Waldrop, 1987). The most basic underlying concept of semantic networks is the simple fact that one idea reminds us of another (Waldrop). Word-association games capitalize on this principle and provide an example of these relationships among ideas, words, or concepts. We can't conceptualize one idea without being reminded of countless others. The definition of one word requires other words to describe the first. The primary focus of semantic networks, as the name implies, is on meanings and organization of words within memory. These words are connected and interconnected, or linked, through complex networks of relationships. Semantic networks rely on these numerous links to connect concepts in a meaningful way. Every word connotes a (unique) meaning to an individual based on these semantic networks. This model of human memory suggests that the definition of a word's full concept would be "all the nodes that can be reached by an exhaustive tracing process, originating at its initial, patriarchical type node, together with the total sum of relationships among these nodes" (Quillian, p. 227). Although these relationships would ultimately be uniquely individual, they are also based on stereotypical relationships and common hierarchical relationships. The earliest descriptions of semantic networks described them as hierarchical structures which organized information in a top-down manner. Collins and Loftus (1975) revised this model and removed the strict hierarchical structure to emphasize spreading activation among nodes (Nelson, 1992).

Concept Webbing/Mapping

The concept web or map is a method of detailing the representation of information within memory. The cognitive concept map is viewed as an *internal* representation of environmental information (Sprinthall & Sprinthall, 1990). *External* visual representations of both semantic networks and concept webs are often used to better portray a concept. Students who are taught to map their understanding of expository material have been shown to not only improve in mastery of the mapped material, but also to improve in general reading ability as well (Geva, 1983). It is generally understood that semantic network visual representations and *concept webs* allow the information to be intertwined and interconnected in a nonlinear fashion (Jonassen, 1989). Harmon and Dinsmore (1992) state that the "semantic network theory holds that people store information in linked web-like structures" (p. 3). The difference in these two models may, therefore, be indiscernible. This nonlinear visual representation of information is the primary principle which supports the development of hypertext.

Web-teaching principles (Jonassen, 1989) involve the initial presentation of a general framework (or web) to which later information can be added. This whole-to-part or general-to-specific approach to teaching is one very common approach. The initial presentation of a framework or outline for learning is similar to *advance organizers*

(Ausubel & Robinson, 1969) and has been widely accepted as a successful approach to teaching.

Frames/Scripting

Minsky (1974) developed the idea of *frames* for information in which we utilize common stereotypes to assist us in new situations. This is explained by Waldrop (1987) through the commonly used *restaurant frame* in which we all expect similar types of behaviors which are deemed appropriate and logical. Waldrop also uses the non-example of an auto accident to depict how people react and behave without common stereotypical frames to follow. People often become frantic, confused, and uncertain of what to do or how to behave. Frames depict a static set of facts and can be explained as a set of expectations within a certain circumstance (Waldrop). Frames are similar to Quillian's (1969) nodes in that they both represent single concepts which can be organized by headings and subheadings. Quillian (1969) used (superordinate) type nodes and (subordinate) token nodes; whereas Minsky used the subheadings of slots or terminals into which incoming information is stored. These units of information are also similar in that both are linked through connections called branches or associative-type links. These gaps in the overall general framework (slots or terminals) are similar to the methods described by the concept web teaching principles. The fact that we often infer certain information even when it was actually missing from the original experience offers proof of how we fill these slots and terminals with information based on prior experiences.

Scripts were developed by Shank and Abelson (1977) and are like frames in that they involve stereotypical expectations, but they differ in that they involve a *sequence* of events or frames (Waldrop, 1987) rather than a single static set of facts. Abbott, Black, and Smith (1985) found that the structure used for the representation of scripts in memory can be best described as a modified hierarchy rather than a serial ordering. This research suggests that items are ordered temporally but within a hierarchy utilizing superordinate nodes which are broken down into more basic script actions.

Schema Theory

Perhaps the earliest usage of *schemes* for representing a method of organizing information is from the works of Piaget. He described schemes as being either behavioral (throwing a ball) or cognitive (realizing the existence of many types of balls). His description of schemes involved the "organized patterns of behavior or thought that children formulate as they interact with their environment" (Biehler & Snowman, 1990, p. 59). For the purposes of providing a theoretical basis for hypermedia and the cognitive processes of thought, this paper will focus solely on the cognitive-type of schemes as described by Piaget.

Schemata (plural of schema) have been described as "data structures that contain abstract information about frequently experienced events" (Kardash, Royer, & Greene, 1988), a set of categories of interpretation, organized information units or more specifically as "interrelated knowledge structures, actively engaged in the comprehension of arriving information, guiding the execution of processing operations" (Rumelhart & Norman, 1978, p. 41). These definitions combined seem to describe schemata as a class of information units or nodes which are closely related in some relative (to the individual) way. These differ from scripts in that they are not sequentially executed actions, but rather a collection of individual nodes, frames, or descriptive traits of a concept that are related in a conceptual way. The validity of these relationships is purely dependent on the owner's experiences and conceptualizations (Rumelhart & Norman).

Schemata have been shown to significantly effect the retrieval of free recall information irrespective of whether the information was initially listened to or read (Kardash, Royer, & Greene, 1988). Since we organize information according to our own schemata, which is based on personal experiences, we selectively attend to the information available to us from our environment. This suggests that schemata also affect the information at the time of encoding which is contradictory to the findings of Kardash, Royer, and Greene whose research suggests that we are able to better remember (recall)

events even if the schemata are formed *after* the exposure to the information. This suggests that the effects of schemata are most influential at the time of recall rather than at the time of encoding. Other research utilizing the "home buyer/burglar passage" as a method of shifting perspective prior to recall has had mixed results as to the effect of schemata on encoding, but the research does agree on the effect schemata have on recall (Alba & Hasher, 1983; Anderson, Pichert, & Shirey, 1983; Anderson & Pichert, 1978).

Terminology has been used to describe these concepts that essentially provides similar and overlapping information. These similarities need to be understood. Semantic networks are also termed *active structural networks* (Quillian, 1968). There are few differences among the following groupings: networking is the same as branching, webbing, and mapping; concepts have been called nodes, frames, words, and ideas; and the relationships among concepts have been called links, connections, relationships, and branches. The primary difference which does exist largely involves the description of knowledge representation as being either linear, nonlinear, temporal, or hierarchical. Regardless of which method of organization one selects as the *true* form, it is noteworthy that these structures are only abstract conceptualizations of how information is stored in memory. The most common similarity among these models is the associative nature of memory which organizes information in meaningful rather than nonmeaningful (i.e., alphabetical) orders. These models also share an emphasis on *prior experience* in learning and uniformly describe the representation of information as uniquely *individual* while sharing commonalities through stereotypes.

From these explanations of knowledge structures, we can infer that intelligence (or an increase in learning) occurs by developing connections between nodes that result in a system of relationships consisting of deeper and more varied linkages among nodes. The greater number of connections that a person would have would determine the totality of their level of knowledge. The use of analogies, metaphors, and examples would act to increase the number and strength of these linkages by creating more connections and interconnections among nodes.

Hypertext

Hypertext is defined as "a database that has active cross-references and allows the reader to *jump* to other parts of the database as desired" (Schneiderman & Kearsley, 1989, p. 3). It is easily understood why the memory models previously mentioned are supportive of this type of nonlinear relationship among concepts. Attempts to conceptualize a hypertext database involve the same network of nodes, hierarchies, and linkages among ideas that are used to represent knowledge within memory. Similar to memory systems, there are numerous methods for connecting ideas and establishing links among nodes. These links can be hierarchical or nonhierarchical. Smeaton (1991) describes three possible methods of organizing information when authoring hypertext; strictly hierarchical, a network, and a combination of the two. Although the most simplistic for the author, a *strict hierarchy* is not the most beneficial for the user due to its inability to make more numerous and meaningful relationships among concepts. The *network* allows multiple linkages between nodes which results in a much richer network of relationships. The advantage of the hierarchical structure is that all links follow an orderly route from general to specific (or specific to general), but this navigational advantage can be easily addressed by the *network* structure as well.

Many library bibliographic systems are utilizing hypertext as a method of presenting information. The user can browse, retrieve, and organize the same information utilizing multiple search patterns. A search beginning with the author, the subject, key search terms, or even the journal and chronological information can ultimately reveal the same information product.

In hypertext, the individual nodes of information are connected via buttons to other related information nodes. The learner is able to branch from node to node while exploring concepts in more and more detail. The most common method of organizing information when authoring hypertext involves using hierarchically organized information and

connecting it in the more easily understood nonlinear fashion using semantic relationships (Smeaton, 1991). Regardless of the nature of these relationships, or the mental model chosen to represent this information, one thing remains evident. The information processing models of human memory and the architectural design of hypermedia systems have evolved from similar origins. These similarities can be utilized to build instruction which will address a wider audience than is typically targeted by traditional instruction.

Hypermedia

"Hypermedia systems extend conventional database design principles by allowing the specification of a wider range of relationships between items of information stored in the system" (Nelson, 1992, p. 7). Hypermedia-assisted instruction (HAI) provides a nonlinear method of establishing relationships which are more meaningful to the individual learner. Traditional forms of computer instruction have utilized linear relationships between and among ideas which have restrained the learner by restricting them to developing narrow understandings of related subject matter in often unrelated ways. The integrated use of sound, video, graphics, and text have combined to establish the hypermedia learning environment as an extremely rich method of instruction capable of formulating more numerous and more meaningful relationships by the learner.

The tremendous amount of information available within a hypermedia environment tempts one to assume that mere exposure to such a system would be beneficial and perhaps suitable for learning. This temptation must be realized and understood so that caution can be taken to ensure that sound instructional design principles are adhered to when developing hypermedia instruction. We cannot simply turn the students over to the computer and through the magic of hypermedia hope that learning will occur. The many benefits available through hypermedia must be understood to ensure that the information availability, structural flexibility, and individual control of the learning process which can be provided in this type of environment will be used in accordance with instructional goals (which should be met). The benefits of incidental knowledge gains, the ability to address individual learning needs, and the richness of information offered by hypermedia should not overpower our proven educational practices. This new tool for the educator should, however, be utilized to its fullest extent within a structured environment suitable for the learner. Admittedly, there are limitations to hypermedia.

Hammond (1989) discusses many of these problems: such as (a) getting lost amid the abundance of information; (b) failing to gain an overview of the information; (c) experiencing navigational difficulties when looking for specific information; (d) poorly choosing paths through the information which result in inefficiency; and (e) coming to grips with interfacing with the computer system. Despite these numerous potential problems, each has a solution which can prevent the user from experiencing these difficulties. It is recognized that a graphical representation of the most recent pathways chosen through a database can help orient the user much in the same way that a map helps guide our direction outside of the computer. These maps should be readily accessible and not so finely detailed that they act to exacerbate the disorientation of the user. By providing these navigational aids, the user is kept from getting lost. There are other techniques for providing a *backtracking* ability such as closing overlapping windows or following a sequential path back through the information (Schneiderman & Kearsley, 1989). These act to orient the learner and provide a visual depiction of relationships. These relationships can also be better understood by looking at the "big picture" in the form of advance organizers and then reviewing these relationships following the user's journey through the information. By using keywords to find specific information, exploring the information in detail, and then backtracking, one should experience fewer navigational difficulties. Although there is the potential for one to neglect predetermined learning goals in pursuit of self-interests, the learner should be provided with a structured set of goals prior to engaging in the HAI so that throughout the instruction there are specific subgoals that help ensure the learner is choosing an appropriate path. Beginning the instruction with a general overview, proceeding to an introduction of the course objectives, following this with an

experiential explanation of the equipment, and providing assistance when needed can eliminate the user's computer anxiety and facilitate interfacing with the equipment. Many of Hammond's problems with hypermedia have been overcome.

Theory and Learning Styles

The theoretical basis for learning style research is the experiential learning theory (Dewey, 1938; Jung, 1926). This theory emphasizes the importance of *experience* in learning and stresses that the role of the learner should be an active one (Lewin, 1935). More recently, Kolb (1984) has elaborated on this importance of experience in learning and development. Kolb's (1985) learning style model describes how experience is translated into concepts which are then used as guides for choices in new experiences. Other learning style models have developed from these same origins. The Myers-Briggs and Canfield multidimensional models of learning style instruments are also based on experiential learning theory. "The essence of the theory is that much seemingly random variation in behavior is actually quite orderly and consistent, being due to basic differences in the way individuals prefer to use their perception and judgment" (Briggs-Myers & McCaulley, 1992, p. 1). These individual differences have become the focus of learning styles research.

Not every student learns in the same fashion. Each has his or her own strengths and weaknesses which must be dealt with throughout the duration of one's academic experiences. Assisting students to overcome deficits and maximize strengths is one goal of education. Research on learning styles has developed from this need to understand and capitalize on these individual differences.

There are numerous models for learning styles which focus on cognitive style variables. An explanation of the historical development of learning styles originates with cognitive style research conducted in the 1940's and 1950's by Witkin. This research led to the formation of concepts of field dependent and field independent *cognitive styles*. In the early 1970's, Kolb expanded this research to include four categories of *learning styles*. In the late 1970's Canfield and Myers-Briggs designed multi-dimensional instruments which provided more detailed information on learning styles. A comprehensive explanation of this historical development has been completed by Tamaoka (1985) and in the biography of Briggs and Briggs-Myers completed by Saunders (1991).

Witkin's Field Dependence and Field Independence

Witkin developed the *Group Embedded Figures Test* (GEFT) to determine individual cognitive style preferences. The GEFT requires one to find simple graphical figures within more complex figures and identifies how an individual integrates information. Field dependent persons rely more on external references; by contrast, field independent persons rely on internal references. These cognitive styles are also recognized as *analytic* (field independence) and *global* (field dependence) attributes which further explain these differing approaches to assimilating information (Ehrman, 1990). The cognitive style literature describes the analytic learning style as the tendency to reduce problem situations to a set of underlying causal relationships. The global style is characterized by a reliance on common sense and intuition while demonstrating a tendency to use a trial-and-error approach to problem-solving. The field independent person perceives objects as whole, whereas a field dependent person focuses on individual parts of the object. The determination of which of these styles is used for the integration of information establishes one's cognitive style. These two types of cognitive style are recognized to be opposite ends of a continuum. It is important to note that there is no relation between cognitive style and intelligence (Tamaoka, 1985). Persons identified with either form of cognitive style can be equally intelligent.

Kolb's Learning Styles

The concept of learning styles differs slightly from cognitive styles in that it focuses more specifically on preferred methods of receiving information in a learning environment (Cranston & McCort, 1985). Learning styles focus more on attitudes and are explained by

Kolb (1971, 1974) through a four-stage model. Kolb's learning styles originate directly from the theoretical background of experiential learning.

Kolb's model describes four different kinds of abilities which are required to be an effective learner. Concrete experience (CE), reflective observation (RO), active experimentation (AE), and abstract conceptualization (AC) are the four abilities which form opposing ends of two separate dimensions (abstract/concrete and active/reflective). From these four abilities, Kolb has identified styles which uniquely characterize the four possible combinations. The four distinct learning styles which Kolb has determined are the *Converger, Diverger, Assimilator,* and the *Accommodator*. It is explained by Kolb (1985) that one is not expected to master each of the four to be a successful learner, but that we are continually faced with decisions which force us to choose between these abilities and cause us to develop individual preferences as to which styles suit us best. We make this determination based on the situation and our place in the continuing process of moving from actor to observer and specific to general involvement. This is not to be interpreted as implying that learning styles are subject to change. From a developmental point of view, the preference of learning style is seen as occurring throughout childhood while becoming relatively stable and permanent by adulthood. The individual's emphasis of abstractness over concreteness and action over reflection provides the scores from *Kolb's Learning Styles Inventory* (LSI) which identify the learner's preferred style of receiving and organizing information.

McCarthy (1989) has written extensively on the unique characteristics of Kolb's four individual styles of learning. She describes the *Converger* as a pragmatist. This type of person relies on common sense and tends to focus on "the heart of things." The *Converger* is well suited to the practical application of ideas. These individuals do best when there is a single best answer or solution to a problem. The *Converger* prefers working with things rather than people, typically does well on intelligence tests, has narrow interests, and is relatively unemotional. Kolb's research shows that this learning style is characteristic of many engineers. McCarthy describes the *Converger* as someone who functions by gathering factual data from hands-on experience.

The *Diverger* excels in areas that require imagination and the generation of ideas (brainstorming sessions). A person with this style of learning is particularly adapted to viewing the learning situation from multiple perspectives and has broad cultural interests. Kolb has found that social science, education/liberal arts, and humanities backgrounds often show this style of learning. McCarthy maintains that these persons are strongly innovative, suited for idea sharing, and highly imaginative. The *Diverger* is people oriented and enjoys watching others while absorbing information.

The *Assimilator* is portrayed by Kolb as a thinker. This type of person is one who creates theoretical models and excels at inductive reasoning. The *Assimilator* is less interested in people and the application of ideas and more focused on the generation of ideas. This style of learning is often found in research and planning departments according to Kolb. McCarthy explains the strengths of the *Assimilator* as creating concepts and models while thinking things through.

The *Accommodator* is more of a risk-taker and is highly adaptive to new situations. Kolb describes the *Accommodator* as someone who is willing to abandon theoretical presuppositions when they do not seem to fit the facts. A person with this style of learning would be likely to rely on intuitive trial and error approaches to problem solving. Although at ease with people, Kolb describes this person as impatient and "pushy" while tending to be "action-oriented." This style is often found in business-oriented positions such as marketing or sales. McCarthy finds this person to be a self-discoverer who relishes change. Strengths possessed by these persons are an ability to get things done and an ability to turn ideas into action.

Multidimensional Learning Styles

Canfield's LSI (Canfield & Canfield, 1976) and *Instructional Styles Inventory* (Canfield, 1980) were developed to measure the multidimensional aspects of both the

learning style of the student and the instructional style of the teacher. Both instruments consist of 16 scales which determine learning and instructional styles. The complexity of these instruments is best suited to providing detailed information concerning the level of congruence between teacher and student styles. These instruments provide data which is useful for instructional counseling (Tamaoka, 1985).

The Myers-Briggs Type Indicator (MBTI) is a learning styles instrument that also distinguishes 16 separate types of learning style (Briggs-Myers & McCaulley,1992). The basis for these 16 types is the four separate preferences outlined in Jungian theory. *Extraversion* or *Introversion*, *Sensing* perception or *Intuitive* perception, *Thinking* judgment or *Feeling* judgement, and *Judgment* or *Perception* are the four categories which define the MBTI. The MBTI requires that the learner choose between the four poles to identify individual learning preferences.

Portions of the MBTI have correlated positively with Kolb's LSI (1976), meaning that the two instruments can be interpreted as measuring some aspects of the same personality preferences. Both instruments trace their origins directly to experiential learning and Jungian theory.

Sensory Modalities

Another area of learning styles research focuses on individual preferences for sensory input of information. Some individuals are better visual learners, others are auditory learners, and some have developed an integrated approach. Modality-based research which examines matching and mismatching modality with instruction, began in the late 1970's, gained momentum and continued into the early 1980's, and has achieved an ever-increasing focus with the application of computers into the instructional setting. Although the majority of this research deals with younger populations, it still has the potential of producing significant implications for older students operating in the arena of computer instruction and education.

This modality-based research also examines the effects of environmental aspects as they affect learning. The lighting conditions of the room, the desirable temperature conditions, food and drink intake, and the use of visual or acoustical aids are all areas of focus for sensory modality research (Ehrman). The Dunn, Dunn and Price (1985) model defines the construct of learning style in terms of how students react to 23 separate elements affecting how people integrate information. These elements can be categorized as environmental, emotional, interpersonal, physical, and cognitive aspects or inclinations. The psychological or cognitive area consists of the global/analytic, impulsive/reflective, and hemispheric styles of learning (Dunn, 1988).

Ausubel (as cited in Sprinthall & Sprinthall, 1990, p. 293) explains that concept formation depends on which characteristics a person chooses to focus upon as well as one's individual method of storing and retrieving information. The dual-code theory of information processing emphasizes a multi-modality approach to instruction which allows information to be received and then reinforced utilizing more than one of the five senses. Since students can have imaging and/or verbalizing preferences this dual-coding is doubly beneficial.

Brain Hemisphericity

The research on brain hemisphericity has developed a popular conceptual model which compares the functions of the left and right sides of an individual's brain. This model recognizes that certain mental tasks are completed solely by one side of the brain or the other. The left hemisphere is viewed as the logical, analytical, linear information processing area of the brain. The right hemisphere is devoted to visual, auditory, tactile, holistic, and emotional aspects of information. Hunter (1976) describes the left side of the brain as specializing in relationships across time and the perception of significance. She describes the right side as the visual-spatial brain which specializes in relationships across space. This type of hemisphericity plays an important role in the selection of occupations and identifies the musician, accountant, artist, farmer, and architect as persons dealing with visual-spatial data. The temporal left-brained person seems better suited to be a

philosopher, salesperson, or theoretician. While some individuals have a strong left or right preference when it comes to integrating information, others develop an integrated approach which utilizes both hemispheres (Ehrman). Gender differences show that males are most often left-brained and that females are typically right-brained. These differences could be expected to decrease with increasing changes in stereotypical behaviors and an increase in androgyny. It is likely that both sides of the brain are necessary to reach higher ability levels in certain skill areas such as language (Leaver, 1987,1990).

The multiple *cognitive style* variables discussed thus far have been suggested to exist within a single dichotomy (Schmeck, 1988) with "global-holistic/field dependent/right brained at one end of a possible continuum and focused-detailed/field independent/left brained at the other" (Ehrman, p. 10). Conversely, *learning styles* have typically taken more complex, detailed, and even multidimensional forms. These individual differences are instrumental in the development of effective instruction. "It is important to know about the strengths and weaknesses of individual students, so that we may adapt our instruction to help them meet their individual learning goals" (Wilson, 1988, p. 326).

The theoretical origins of both hypermedia and learning styles do not conflict. In fact, they intertwine and are supportive of each other. Dewey (1938) describes learning as building and connecting experiences in a meaningful way for the learner. Information processing models of knowledge representation also emphasize building more elaborate networks, schemata, and scripts. Although Jung's (1926) development of psychological types is directly supportive of the development of learning styles, it is also relevant to the information processing models' emphasis on uniquely individual relationships and schemata among the many stereotypical relationships shared by others.

It is my contention that these two theoretical origins cannot be separated, nor should they be. Efforts should be made to mutually apply the two.

Application of CAI/HAI and Learning Styles

Despite the fact that computers have been heralded as the solution to individualizing instruction for over a decade, as recently as 1990 it has been recognized that too few researchers "are exploring the vast potential of the computer as a means to accommodate the preferred learning styles of individual students" (Geisert, Dunn, & Sinatra, 1990, p. 297). From the paucity of literature which does exist, the use of the computer as an instructional tool and the relationship to research on individual learning styles appears to be an exciting area of development holding great promise. It is hoped and anticipated that hypermedia will bridge this gap between learning style and computer. Hypermedia is believed to accommodate different learning styles and different entry levels of skill because of its flexibility and high level of learner control (Liu, 1992). Bridging the gap between computer and learning style may be possible by presenting materials to be learned in a way which encompasses individual differences in learning style. Ideally, this will involve providing such a rich design and presentation of instruction that all types of learning styles will be addressed.

Learning Styles and CAI

Learning styles and computer-assisted instruction (CAI) is one area of recent research. Two themes have emerged from this research. One is the recurring confirmation of a relationship between learning styles and computer instruction. This relationship varies according to which learning styles (and cognitive styles) are examined, but essentially there are differences in computer performance according to these individual preferences (Stevens, 1983). The second theme is that there is a negative effect when mismatching mode of CAI and learning style or, conversely, a positive effect when these variables are appropriately matched (Martini, 1986; Rowland & Stuessy, 1988).

Riding, Buckle, Thompson, and Hagger (1989) examined the relationship between modality-based learning styles (verbal and imaginal) and performance on textual and pictorial materials presented through computer-based training (CBT). The *verbalizers* were found to perform much better on textual information and *imagers* performed substantially better with pictorially presented information. The mode of information presentation is

optimal when matched to learning style. The authors point out that high ability mathematics students with the imager style of learning are able to perform reasonably well with information presented in either pictorial or verbal form. This suggests that the high ability students may simply be better able to combine multiple sensory modalities, whereas the low ability student may not have yet mastered the verbal skills necessary to "pick-up" on these cues. The low ability imager students tend to over-rely on appearance information while the verbalizers over-rely on textual information. Both low ability groups' styles appear to sacrifice one form of information gathering at the expense of the other, whereas the high ability students are better able to combine these methods of information gathering through multiple sensory modalities.

Hativa and Reingold (1987) examined the importance of audiovisual stimuli on learning through microcomputer-based instruction. Students who learned with audiovisual (involving color, sound, and animation) instructional software performed better than those who learned with no-stimulus instructional software (black/white, no sound, and no animations). Although this is evidence of the importance of stimulus materials used in CAI, this study did not group students according to individual learning preferences. No consideration was given to individual learning style differences which may have identified persons more, and less, suited to learning in each of the stimulus/no-stimulus conditions.

Rowland and Stuessy (1988) conducted an exploratory study that found matching mode of CAI (tutorial or simulation) to individual cognitive style (*holist*/global/whole-to-part and *serialist*/analytic/part-to-whole) produces significantly more effective learning with computers. The *serialists* were found to have difficulties learning with simulation types of software while the *holists* were found to have difficulty learning with tutorial types of software. When individuals were appropriately matched to mode of CAI, they performed significantly better than when mismatched. Holists favored simulation-type software and serialists tended to perform better with tutorial-type software. The effect of cognitive style on mode of CAI performance clearly reveals the benefit of appropriately matching these two variables in the learning environment.

Martini (1986) investigated the effects of matching and mismatching instructional methods on science achievement of seventh-grade students according to learning style perceptual preferences. All students performed significantly better when appropriately matched to the preferred sensory modality form of instruction, and all students achieved better with CAI than with auditory or visual forms of non-computer instruction. Again, the relationship between learning style and computer instruction appears especially powerful when the two variables are appropriately matched.

Cordell (1991) examined the effect of learning styles and two forms of CAI design on the outcomes of learning. This study utilized Kolb's 4MAT LSI with linear or branching CAI designs. There was no difference in performance among the four learning style types, and there was no relationship found between learning style and instructional design. Although not significant, there tended to be better performance with branching CAI by the *Assimilators* and *Divergers* while the linear CAI was favored by *Accommodators* and *Convergers*. These groupings are congruent with Kolb's explanation of these styles and theoretical underpinnings from the learning styles research; however, the results of this study did not reach significance in supporting the research hypotheses. There are several possible reasons for this. The length of treatment for this study was extremely abbreviated with each participant completing a tutorial program which typically lasted no longer than one hour. Other design limitations involved no clear distinction between CAI designs (the branching and linear designs may not have been dissimilar enough to make clear distinctions), scoring limitations of the performance measure, and subject selection. Because of these various limitations and a lack of significant findings, generalizations from this research would seem suspect.

It is evident that students perform better in a computer learning environment when the design of instruction is appropriately matched to their particular learning style. The differences in computer performance by individual learning style have been shown to be

dependent upon (1) instructional design, (2) mode of CAI, (3) reduction of computer anxiety and (4) the individual differences in prior experience and ability. The problem now becomes one of accommodating such a diversity within our classroom.

Learning Styles and HAI

Multidimensional learning style instruments can identify as many as *16 different types* of learning styles (Briggs-Myers & McCaulley, 1992; Canfield, 1980). Rather than adapting the presently existing instruction to this diverse audience, the initial design of the instruction should incorporate these individual styles of learning. Presently, the best method of achieving this goal is to develop the instruction so that it encompasses many different styles of learning within its rich design. "If an instructional program is rich enough, it will provide sufficient diversity to meet the needs of all learners, and comprehensive instructional models that allow for such diversity have been developed" (Stice & Dunn, 1985). Hypermedia is one such model. To ask a teacher to adapt her instruction to so many varied individual learning styles would not be feasible in a typical classroom. The teacher's style of instruction cannot be expected to address such a diversity of student learning styles. Hypermedia can assist the instructor in this endeavor.

The ability of the computer to address each student individually is seen as an advantage by many. The possibility of combining stimulus materials into a multiple sensory modality approach to computer education merits attention.

Barba and Armstrong (1992) examined two types of HAI utilizing eighth-grade earth science students. One type of instruction was augmented by a HyperCard tutorial and the other form of instruction consisted of the same HyperCard tutorial with the addition of interactive video. Although there was no significant difference in performance for the two forms of instruction, there was a significant difference for the low verbal ability group which performed best with the interactive video augmented design of instruction. Learning styles were not assessed as part of this study; however, it is important to note that the different sensory modalities addressed by the two forms of instruction did make a significant difference for the low verbal ability students. The visual reinforcement (interactive video) of the tutorial information was sufficient to create significant differences in performance for those students who obviously rely on visual information to understand the concepts targeted by instruction.

Overbaugh (1992) examined the use of hypermedia to instruct pre-service teachers in classroom management techniques and practices. He used interactive video to portray actual classroom scenes depicting classroom management problems. These scenes were used in short clips after which the student would respond to questions which then determined the nature of the next scene. The design of this instruction allowed the student an opportunity to explore the consequences of one's classroom management decision in a realistic, but safe, environment. Feedback was given to the student based on each decision throughout the course of the instruction. An important feature of the program was that the students were allowed to type in short answer/essay responses which were individually saved and reviewed prior to leaving the program. Following each response, the student was presented with a menu to choose the item that most closely resembled their response. Actual classroom management principles were not only viewed, but also defined and evaluated for effectiveness. There were 148 possible conclusions which could be reached from the four scenarios presented by this instruction. Overbaugh applied this form of hypermedia instruction to a sample of pre-service undergraduate education majors. These participants were identified by learning modality using an inventory developed by Barbe and Malone (1980) which describes the learner as auditory, visual, kinesthetic, or a combination of these. The two learning modalities of auditory and visual were used to examine possible differences for achievement. There was *no significant difference between the two learning preferences* on achievement. The hypermedia-based instruction was equally effective for either modality. This implies that hypermedia can encompass a diversity of students with differing preferences for learning.

Liu (1992) utilized HAI to instruct second language learning for graduate and undergraduate international students learning English. The HAI consisted of a HyperCard program which utilized interactive video and clips of the film *Citizen Kane* to instruct linguistic features, vocabulary, and the appropriate use of the English language via *real-life* examples. The learners were exposed to video, graphics, sound, and text to explain parts of speech, sentence examples, context of language use, and definitions. Participants were identified as field dependent, field independent, or mixed using Witkin's *Group Embedded Figures Test*. The results of this study revealed that *regardless of which style of learning the student was identified as having, the hypermedia instruction resulted in uniformly significant pre- to posttest gains in language performance.*

The difference between CAI and HAI as they relate to learning styles is simple. With CAI, as in noncomputer-based learning, the instruction must be modified or the learner must adapt in order for the learner and instruction to best suit each other. Conversely, "hypermedia-based learning environments allow the knowledge base to accommodate the learner rather than the learner accommodating the knowledge base" (Nelson & Palumbo, 1992, p. 288). CAI has attempted to adapt to these differences. HAI has attempted to overcome and encompass them.

Future Research

It may be important to note that both Overbaugh (1992) and Liu (1992) designed, created, and implemented the hypermedia instruction previously described. As hypermedia develops, there will be a wealth of instruction to choose from which will alleviate the requirement of creating one's own. Conversely, the relative simplicity and ease of creating one's own hypermedia instruction is becoming less arduous with the recent advancements in software oriented to the creation of hypermedia instruction. *Authorware*tm, *VideoSpigot*tm, and *Adobe Premiere*tm are some examples of this type of software.

It has been shown that matching learning style and CAI produces the most effective increases in performance. From a broader perspective it would seem almost commonsensical that when we match any instruction to the learner we will achieve the best results. The problem to date has been our inability to individualize instruction to address this broad diversity among students. Hypermedia appears to hold much promise, and in fact has proven effective, at addressing this student diversity. Future research should explore additional learning style instruments in relation to student achievement in a hypermedia environment. A variety of content areas should be explored to fully understand the broad applicability of hypermedia as it addresses these multiple learning styles.

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